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Investigation of lower thermosphere dynamics in the MAC/SINE period using radiometeor measurements in Kazan

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Abstract—This paper presents the experimental results for the circulation in the 80–110 km height region obtained at Kazan State University in the period of the MAC/SINE International Campaign in 1987. A zonal wind reversal was recorded at heights of about 89 km, with easterly winds below 89 km, and westerly winds above 89 km; for tidal motions, the amplitude and phase modulation were defined. The presence of waves with scales representative of tidal and synoptic motions is typical for zonal and meridional circulations in the summer period.

INTRODUCTION

The International Campaign MAC/SINE 1987 was conducted in order to investigate the thermodynamic conditions in the middle atmosphere in summer. The radiometeor method was used at Kazan University to investigate the characteristics of the prevailing circulation and atmospheric waves for temporal scales from internal gravity waves up to planetary waves. The equipment is an automatic radar system with a phase height measurement device which is described in detail in SIDOROV and FAKHRUTDINOVA (1981). The basic technical parameters of the radar system are as follows: working frequency 32 MHz, pulse duration 100 ms, pulse repetition frequency 400 Hz, transmitted pulse power 200 kW with 'wave channel' type transmitting and receiving antenna. The method of observation is the so-called azimuthal one with the consecutive four azimuths (N, E, S, W) used to probe the meteor zone. The areas probed in opposite azimuths are spaced 400 km from each other. The phase altimeter provides height measurements with a root-mean-square error of 1 km.

The main results on the dynamics in the 80–110 km height region obtained at the radar station (56°N, 49°E) in summer (15 June–30 July 1987) are given below.

PREVAILING MOTIONS

As can be seen from the results of the measurements, prevailing and tidal motion parameters have been derived using the method of harmonic analysis as well as the least-squares method.

For the zonal circulation there is typically a change from easterly to westerly winds near 89 km. In the height interval below 89 km the mean monthly values are about 20 m s^{-1}.

The observed wind reversal at the height of ~90 km is typical for the summer season and is of global character. This is evident by comparing the results of summer observations in 1986 and 1987 in Kazan and Harkov (50°N, 36°E) (OLEINIKOV and FAKHRUTDINOVA, 1987) and the results of the observations by the Saskatoon MF radar system in 1979–1982 and 1984 (52°N, 107°W) (MANSON *et al.*, 1985; MANSON and MEEK, 1986).

Northerly winds are typical of the mean monthly meridional circulation in the 80–110 km height interval; major changes in the northerly winds are observed in the 80–89 km height region. Mean monthly data of prevailing winds of zonal and meridional circulation are given in Fig. 1.

Quasi-two-day wave observations and wave observations (WE) with synoptic periods are present in interdiurnal variations of prevailing wind of zonal and meridional circulations. Wave intensity with synoptic scales is sufficient to cause a change in the prevailing components during the course of 2–3 days. The existence of southerly winds in the whole height interval in the period 19–21 June, westerly winds at the heights of 80–89 km, and easterly winds at the heights of 89–110 km observed during 20–21 June testify to this. The observed wind direction change is the consequence of zonal and meridional circulation with periods of 6 days and amplitude of 30 m s^{-1}.

Height variations of wave excitation phases with synoptic scales testify to the presence of critical layers in the height region of 80–110 km, where a marked change of the direction of wave propagation is observed. The critical height levels vary with wave frequency.